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ABSTRACT

A study examined how both children and adults process inferences when reading prose. Subjects, 24 third-, fifth-, and eighth-graders, and adults, read stories where a consequence was implied, and then answered questions. The stories differed in the degree to which the inference was necessary for comprehension, and the readers engaged in either superficial or more integrative reading. Results supported the hypothesis that inferences necessary for comprehension would be generated during encoding while more elaborative inferences would not be drawn until test time. Even the youngest children successfully drew the inferences. While reading times and question-answering latencies decreased with each higher grade level, the pattern of results was identical for all age groups. In addition, the integrative reading condition prompted slower reading and question-answering times for the two younger groups, while the reverse held true for the two older groups. The pattern suggests that integrative reading taxes young readers' attentional resources or working memory capacity, with performance mimicking results often seen with elderly adults. (One figure and four tables of data are included. Thirty-one references are attached.) (Author/MG)

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The Effects of Textual Support and Reading Goal on the Loci of Children's Inferential Generation

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Author Notes

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Running head: THE EFFECTS OF TEXTUAL SUPPORT

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Abstract

This study examined how both children and adults process inferences when reading prose. Third-, fifth-, and eighth-graders, and adults read stories where a consequence was implied, and then answered questions. The stories differed in the degree to which the inference was necessary for comprehension, and the readers engaged in either superficial or more integrative reading. The results supported the hypothesis that inferences necessary for comprehension would be generated during encoding while more elaborative inferences would not be drawn until test time. Even the youngest children successfully drew the inferences. While reading times and question-answering latencies decreased with each higher grade level, the pattern of results was identical for all age groups. In addition, the integrative reading condition prompted slower reading and question-answering times for the two younger groups while the reverse held true for the two older groups. The pattern suggests that integrative reading taxes young readers' attentional resources or working memory capacity, with performance mimicking results often seen with elderly adults.

The Effects of Textual Support and Reading Goal on the Loci of Children's Inferential Generation

Researchers who study the development of prose comprehension agree that the ability to generate inferences is an important skill that determines, to a large extent, the degree to which a passage will be understood. Indeed, inferences often play an integral role in linking together the various sentences of a passage (Zabrucky, 1986) or in filling in elements or events which are missing from the explicit story representation (Omanson, Warren, & Trabasso, 1978). Prose comprehension, therefore, represents more than simply the sum of its parts - the comprehension of each successive sentence (Black & Bern, 1981; Johnson & Smith, 1981). It represents the potential for added elaboration which goes beyond explicitly given information. This important relationship between inferential generation and prose comprehension is easily evidenced by the fact that writers often implicitly assume that the reader will draw inferences that fill in the missing elements of a story. (Black, 1981; Millis, Morgan, & Graesser, 1990; Seifert, Robertson, & Black, 1985).

Given the critical nature of inferences to the overall comprehension of prose passages, one could reasonably ask when such inferences are drawn.

There are two distinct possibilities. On the one hand, it could be that inferences are an encoding phenomenon, explicitly generated by the reader as a passage is read. Conversely, it is also possible that inferences occur at retrieval and are, therefore, not encoded when the original memory representation is formed.

A conceptualization advanced by a number of researchers working with adults (i.e., Dosher & Corbett, 1982; McKoon & Ratcliff, 1986; Potts, Keenan, & Golding, 1988; Singer & Ferreira, 1983) may help distinguish when various types of inferences are generated. This view posits that inferences which are necessary for integrating separate propositions within a passage to produce a coherent memory representation (commonly called "backward" or "bridging" inferences) are much more likely to be drawn at encoding than are inferences which are more optional in nature (commonly called "forward" or "elaborative" inferences). The work of Potts et al. (1988), for instance, examined whether passages which strongly implied a consequence inference would facilitate the naming of the inference word. For example, consider the following passage: "No longer able to control his anger the husband threw the delicate porcelain vase against the wall. He had been feeling angry for weeks, but had refused to seek help." After reading this passage, subjects were presented the target word

"broke," and asked to name it as quickly as possible.

With this naming task, Potts et al. (1988) found no evidence that the inference was primed by the passage. Significant priming was only obtained with "coherence inferences," which were inferences which were highly suggested by the presence of additional supporting text, but which were never explicitly stated (i.e., backward inferences). An instance of a coherence inference would be created in the above example by replacing the second sentence with "It cost him well over one hundred dollars to replace the vase." Potts et al. concluded that inferences which are highly predictable are probably not drawn during the reading of text, unless those inferences are actually required for textual coherence, as were their coherence inferences.

Unlike the adult research, however, there is little developmental research which has examined the locus of inference generation issue. This is unfortunate, as children may be especially affected by the presence of inferences necessary for story comprehension. If the appropriate inferences are not generated during the course of reading, comprehension may well suffer due to the disjointed nature of the passages. Unfortunately, the only three studies to date which have concerned themselves with the issue of encoding vs. retrieval have either not compared necessary inferences against optional inferences

(Danner & Mathews, 1980; Thompson & Myers, 1985), or have suffered from methodological difficulties (Casteel & Simpson, in press).

The present study therefore represented an attempt to address this issue of inference "necessity" by constructing stories which made an inference either optional or necessary to textual coherence. Stories were constructed which contained three versions. In the "forward inference" versions, a consequence inference was strongly implied, but was not necessary to understand the passage as a whole. In the "backward inference" versions, the same consequence inference was followed by additional text which supported the generation of the inference, and in a sense forced the inference to be drawn. In these versions, if the appropriate inference was not drawn, the story should have been disjointed. Finally, in the "explicit inference" versions, the inference was explicitly mentioned, and these versions therefore functioned as controls. A sample story is presented in Table 1.

Insert Table 1 about here

In the present study, the dependent measure which most directly addresses the locus of inference generation is reading time. If an inference is drawn at

encoding, then this should be reflected by an increase in cognitive processing which manifests itself as a slowing of the reading process. While the use of this measure is not new (e.g., Carpenter & Just, 1977; Haberlandt, Graesser, Schneider, & Kiely, 1986; Kail & Bisanz, 1982; Keenan & Kintsch, 1974; Millis et al. 1990; O'Brien, Shank, Myers, & Rayner, 1988) what is novel is the way in which it will be applied to study inferential processing.

In both the backward versions and the explicit versions, the final sentences of each passage were identical (the inducing sentences). In the backward versions, the final sentence made the inference highly compelling, so it should be here that reading time is slowed, reflecting the additional processing. In the explicit versions, since the inference was explicitly stated, reading times to this last sentence should be quicker, as no additional inferential processing is necessary to understand it.

Before turning to a discussion of the actual experiment itself, a final issue needs to be raised which may play an important role in mediating whether or not children do in fact draw inferences at encoding. Recently, a number of authors have suggested that a reader's goals or purposes in reading a passage may play a critical role in determining whether particular inferences are made at encoding or at retrieval (Black, 1981; Graesser, Haberlandt, & Koizumi,

1987; Just & Carpenter, 1980; Mosenthal, 1976-1977; Reder, 1980; Whitney, 1987; Zabrucky, 1986). Most of the developmental studies that have attempted to influence a child's comprehension of prose passages have generally looked at the effect of adjunct questions, either presented before, during, or after a passage is read. However, while research has shown that such questions can aid a child's textual integration (see Reder, 1980, for a good review), the most effective questions seem to be those which force a child to use newly learned information. As a result, the emphasis has been on the retention and application of factual information rather than the integration of more narrative passages (Reder, 1980).

Research with adults suggests that it is possible to induce subjects to integrate text toward fuller comprehension through the use of memory instructions (Black 1981; Zabrucky, 1986). Stressing textual integration may make it easier for young readers to link sentences needed to draw appropriate inferences. Second- or third-grade subjects may not normally draw backward inferences at encoding because they treat inference clues as isolated pieces of information (i.e., Schmidt & Paris, 1983; Schmidt, Schmidt, & Tomalis, 1984). A reading goal that stresses textual integration might be successful in prompting such subjects to link together sentences at encoding that they otherwise would

treat in an isolated fashion. As a result, their ability to answer questions probing that information should be facilitated.

This hypothesis was addressed in the present study by having one-half of the subjects engage in an integrative type of reading process, while the other half engaged in more superficial reading. After reading each story, half of the subjects at each grade level were asked a question whose answer depended upon an appreciation of the events in the story. This constituted the integrative reading goal condition. The other half of the subjects, who were in the superficial reading goal condition, were told to pay special attention to a capitalized word which would appear in each story. They were told to expect a recognition test of each of these words immediately after each story was read.

Method

Materials

In an attempt to control for the effects of prior knowledge about the likely consequences of common events, all of the stories were constructed from inference sentences previously normed in Casteel and Simpson (in press) for both second-graders and adults. Only inferences which obtained an 80% level of agreement were used in the present study. Forty four-sentence stories were constructed, 24 of them implying a consequence (the experimental stories), with

the remaining 16 constituting filler. Each story consisted of three versions: forward, backward, and explicit. The sentence implying the consequence was either presented in the last sentence of the story (forward inferences), was followed by a sentence consistent with the story which did not refer to the inference (backward inferences), or was followed by a sentence which explicitly mentioned the consequence (explicit inferences). The final sentences in the backward and explicit versions, known as the "inducing sentences," were identical, with the only distinction being the final sentence "forced" the inference in the backward versions while it provided a logical continuation to the consequence inference which had been explicitly mentioned in the explicit versions. The three versions were also equated for the number of times words semantically associated to the inference appeared in each, as suggested by Keenan, Golding, Potts, Jennings, and Aman (1990).

Eight stories of each type were randomly assigned to an experimental list. These 24 experimental stories, coupled with the 16 filler stories, constituted List 1. Two additional lists were constructed by pairing the alternate versions of the List 1 stories with the 16 filler stories. In this way, three experimental lists were constructed, with one version of each story appearing once in each list. The 16 filler stories were common to all three lists. The stories were presented

in a single random order to all subjects.

The 16 filler stories were similar in form to those of the experimental stories, but did not present any implicitly stated actions. The inclusion of these filler stories aided in concealing the true intent of the experiment.

Two questions were written for each story. For the inference stories, one question probed inferential information while the other probed filler information. Each type of question appeared equally often in the first position. Both questions probed filler information in the filler stories. Inference questions were always intended to be answered "yes," while correct answers to the filler questions could be either "yes" or "no." Across all stories, the number of "yes" and "no" answers were equated.

Stories read by subjects in the superficial reading goal condition always contained one capitalized word. For the inference stories, the capitalized word was always drawn from the two sentences which were common to every version. For the filler stories, the capitalized word came from one of the first three sentences. In all cases, word semantically associated to the inference term were never capitalized.

Subjects

The sample consisted of 12 males and 12 females from grades 3, 5, and 8, and adults. The mean age of the groups were 9-3, 11-2, 14-2, and 25-6, for grades 3 through adult, respectively. Only students rated by their reading teachers as representing "average" reading ability were included. The adults were drawn from students enrolled in psychology courses who attended an urban university.

Procedure

Presentation of the Stimuli.

Each session was conducted individually with the subject seated a comfortable distance of their choice in front of a video monitor. The presentation of the stimulus materials and the recording of the reaction and reading times was controlled by a Commodore PET 2001 Series computer.

Each subject saw a total of 44 stories, with the first four constituting practice. Utilizing a subject-paced reading paradigm, each story was presented one sentence at a time. The subject was required to press a key on a response box interfaced with the computer to control the presentation of successive sentences. After the initial key press, a series of four double-spaced lines of dashes appeared, with the length of each line corresponding to the actual length of the sentence being masked. A cursor flashed in the upper left-hand

corner of the first sentence of the story, and acted as a fixation point. After 1.5 seconds, the first sentence of the story was unmasked. After reading the first sentence, the subject pressed the response key. The first sentence was re-masked, and the second sentence was revealed. This procedure continued until the subject had read the entire story.

After each story was read, the questions were presented one at a time, centered on the screen. Each question was preceded by the word "Question" centered at the top of the screen. After 1.5 seconds the first of the two questions was presented in the middle of the screen, and remained on until the subject's response. The second question was then presented after a delay of 3 seconds. Subjects responded to the same response box which controlled presentation of the stimulus sentences. A "yes" response was signaled with the index finger of the subject's dominant hand, while a "no" response was signaled with the other index finger. Each subject was asked to respond as quickly as possible without error.

Reading Goal Manipulation.

After the questions following each story were answered, each subject engaged in their appropriate reading goal manipulation task. Subjects in the superficial reading goal condition took part in a forced-choice recognition test

where they were asked to choose the word which had been capitalized in the previous story. The two distractors consisted of words which were consistent with the overall gist of the story and which were similar in length to the target words. All words were presented in the window of a cardboard slider. The subjects were simply asked to tell the experimenter which of the three words had been capitalized in the most recently read story.

Subjects in the integrative reading goal condition were asked to respond into a tape-recorder to a continuation question presented verbally to them by the experimenter. The questions were formed such that an appropriate answer depended upon story integration, and were of the general form "What happened next?" Each question was sufficiently different, however, so that the subject would not spend reading time actually formulating an answer. Previous work by Keenan, Baillet, and Brown (1984) has shown that subjects given the same continuation question after every story actually spend reading time on the final sentence of each story formulating answers to the questions. Subjects in both reading goal conditions then pressed the return key on the computer keyboard when ready to proceed with the next story.

Results and Discussion

Three separate analyses were conducted on all of the data. In the first analysis, mean reading speeds to the fourth sentences in the backward and explicit story versions were compared. In the second analysis, question-answering latencies to the three types of story versions (forward, backward, and explicit) were compared. Finally, the third analysis compared error percentages for the three story versions.

Two analyses of variance (ANOVAs) were performed on each of the three dependent variables of interest. The first treated subjects as a random effect (F_1) while the second treated stories as a random effect (F_2). Only those effects significant by both F_1 and F_2 will be reported.

Reading Speed

The mean reading times to the fourth sentences in the backward and explicit stories for each grade and condition are shown in Table 2. The reading speed data were subjected to a grade (4) X condition (2) X inference type (2) mixed ANOVA. For the subjects analysis, inference type (backward or explicit) was within-subjects while the between-subjects factors were grade (third, fifth, eighth, and adult) and reading condition (superficial and integrative). For the analysis treating stories as a random effect, all factors were within-stories.[1]

Insert Table 2 about here

The main effects of grade and inference type were significant: grade, $F_1(3,88) = 15.11$, $p < .001$, $F_2(3,66) = 102.61$, $p < .001$; and type, $F_1(1,88) = 27.63$, $p < .001$, $F_2(1,22) = 18.17$, $p < .001$. With regard to the type effect, the data revealed that the fourth sentences in the backward versions were read more slowly than the fourth sentences in the explicit versions. The main effect for grade is qualified by a significant interaction between grade and reading condition, $F_1(3,88) = 3.38$, $p < .05$, $F_2(3,66) = 21.20$, $p < .001$. This interaction was examined by comparing age-related changes within each of the two reading conditions. In the subjects analysis, there were no differences among the four grades in the superficial reading condition, although there were differences in the integrative reading condition, $F_1(3,88) = 15.52$, $p < .001$. Newman-Keuls analyses revealed that each succeeding grade level read more quickly than the preceding one, with the exception of the eighth-grade and college subjects, who did not differ. In the stories analysis, there were grade effects for both the superficial and integrative reading conditions: superficial, $F_2(3,66) = 8.97$, $p < .001$; and integrative, $F_2(3,66) = 87.24$, $p < .001$. In the

superficial condition, Newman-Keuls analyses showed that stories read by third graders were slower than those read by all other groups. None of the other differences were significant. In the integrative condition, stories read by each succeeding grade level were quicker than those read by the preceding grade, with the exception of the data involving eighth graders and adults, which did not differ.

There were two main findings which emerged from these reading speed analyses. First, the effect of type showed that backward inducing sentences were read more slowly than the explicit inducing sentences, at all four age groups, implying that additional processing must have occurred for the backward versions, even for the youngest readers. Second, the picture which emerged from examination of the grade by condition interaction data was that more developmental improvement was noted for the integrative stories as compared to the superficial stories. The decrease in reading times from third grade to adult for reading the fourth sentences of stories in the superficial reading condition was only 535 msec, while it was 1230 msec for stories in the integrative reading condition. It appears as if the two younger groups of children had an especially difficult time reading stories in the integrative condition.

Question-answering Latencies

The mean reaction times for each type of inference question, grade, and condition are shown in Table 3. The reaction time data were subjected to a grade (4) X condition (2) X inference type (3) mixed ANOVA. In the subjects analysis, question type constituted the within-subjects factor. In the stories analysis, all factors were within-stories.[2]

Insert Table 3 about here

The main effects of both grade and question type were significant: grade, $F_1(3,88) = 46.82$, $p < .001$, $F_2(3,48) = 76.26$, $p < .001$; and type, $F_1(2,176) = 3.33$, $p < .01$, $F_2(2,32) = 19.33$, $p < .001$. Type was not involved in any interactions, and Newman-Keuls multiple comparisons performed on the F_1 data showed that explicit inference questions were responded to more quickly than backward inference questions, which in turn were responded to more quickly than forward inference questions. In the F_2 analysis, Newman-Keuls analyses showed that the explicit inference questions were responded to more quickly than either the forward or the backward inference questions, while these latter two did not differ from one another (although the difference was in the same

direction as that noted in the subjects analysis).

The main effect of grade was tempered by a grade by condition interaction, $F_1(3,88) = 3.34$, $p < .05$, $F_2(3,48) = 17.09$, $p < .001$. This interaction was further examined by looking at the reaction times of the four grades at each of the two reading conditions. Both of these simple effects analyses were significant: grade at superficial reading condition, $F_1(3,88) = 4.49$, $p < .01$, $F_2(3,48) = 42.50$, $p < .001$; and grade at integrative reading condition, $F_1(3,88) = 12.24$, $p < .001$, $F_2(3,48) = 136.87$, $p < .001$. Newman-Keuls analyses revealed that the effects were similar in both reading conditions, although they appear to be stronger in the integrative reading condition (at least in the subjects analysis). For the superficial reading condition in the F_1 analysis, the third graders responded more slowly than either the eighth graders or adults, with no other significant differences. In the F_2 analysis, questions answered by third-grade subjects were responded to more slowly than questions answered by any other grade level. In addition, questions answered by fifth-grade subjects were answered more slowly than questions answered by either eighth-grade subjects or adults. Finally, questions answered by the adults were actually answered more slowly than questions answered by the eighth-grade subjects.

In the integrative reading condition in the F_1 analysis, each succeeding age level responded more quickly than the preceding one, with the exception of the eighth-grade students and adults. Again, the adults actually responded more slowly than the eighth-grade students, although this difference was not significant. The patterns of significant in the F_2 analysis were identical to those in the F_1 analysis.

The picture which emerged from the question-answering latency analyses converges nicely with that which emerged from the reading speed analyses. The subjects had more difficulty answering forward inference questions than answering backward inference questions. The interpretation of this finding is that the backward inference questions were easier to answer because the appropriate inference was generated during the course of reading (encoding), while the forward inferences were not generated until question time (retrieval). The reading speed analyses would corroborate this conclusion. The pattern of results examining the grade by condition interaction in the subjects analysis also suggests that an integrative reading task causes more problems for younger children than does a more superficial reading task. Differences among the four grades were again more pronounced in the integrative reading condition than in the superficial reading condition. In the superficial condition, the decrease in

question-answering latencies from grade 3 to adult was 875 msec while it was 1750 msec in the integrative condition. This mirrored the pattern discovered in the reading speed analyses.

Error Percentages

The mean error percentage rates for grade, condition, and inference type are listed in Table 4. A grade (4) X condition (2) X inference type (3) mixed ANOVA was performed. In the subjects analysis, inference type was again the within-subjects factor. In the analysis treating stories as a random effect, all factors were again within-stories.[3]

Insert Table 4 about here

Both the main effects of reading condition and inference type were significant: condition, $F_1(1,88) = 6.81$, $p < .01$, $F_2(1,23) = 5.35$, $p < .05$; and type, $F_1(2,176) = 106.13$, $p < .001$, $F_2(2,46) = 26.19$, $p < .0001$. The reading condition main effect revealed that fewer errors were made in the integrative condition than in the superficial condition.

Inference type was involved in a significant interaction with grade, $F_1(6,176) = 2.54$. $p < .05$, $F_2(6,138) = 3.10$, $p < .01$. Inference type was

therefore examined at each grade level, and the results of all four grades are very comparable. Inference type was highly significant at all four grades in the subjects analysis, $F_1s(2,176) = 11.34, 33.94, 24.20$, and 45.75, for third through adult, respectively, all $ps < .001$. Inference type was significant in the stories analyses as well, $F_2s(2,138) = 4.25, 12.09, 8.37$, and 16.30, for the third through adult data, respectively. The third grade data are significant at the .05 alpha level, with all other $ps < .001$. Newman-Keuls analyses conducted on the subjects data showed that a common pattern of responding occurred for grades three, five, and adult, where Forward > Backward > Explicit. For the eighth-graders, error percentages to the backward questions equaled those of the explicit questions, while both were significantly less than the error percentages made to the forward questions.

A similar pattern was reflected in the stories data, where the pattern of data from the fifth- and eighth-grade students and adults mirrored that obtained in the subjects analysis. For the third-grade students, the only difference noted was between the forward and explicit stories, where more errors were noted in the forward stories. There were no differences between the forward (.37) and backward (.18) stories, or the backward and explicit (.07) stories, though the differences were clearly in the same direction as in all of the other grades.

The results of the error percentage analyses clearly show that more errors were made to the forward inference questions than to the backward inference questions. This was true for all four of the grade levels. While the third grade data in the stories analysis did not show a statistically significant difference between the two types of questions, the overall pattern was certainly in the same direction.

As a check of whether the third-grade children were successful in drawing the inferences more often than chance (.50), t tests were conducted on the forward and backward inference data. For the forward inferences, the results were significant, $t(23) = 6.56$, $M = .32$, $p < .001$, indicating that errors to the forward inference questions were indeed occurring less often than chance would predict. The backward inferences exhibited the same pattern of responding as well, $t(23) = 7.43$, $M = .23$, $p < .001$. Error rates to the filler questions were also analyzed, in order to rule out the possibility that the subjects had simply adopted a response bias to answering "yes." Recall that the filler questions required a "no" response. The error rates to the filler questions were also found to be significantly less than chance, $t(23) = 41.44$, $M = .09$, $p < .001$.

Post-hoc Analyses

Sentence Reading Speed Effects

Although the results suggesting that the backward inferences were drawn during reading are compelling, it could be argued that the slow-down for the processing of the backward inferences was due to textual factors completely unrelated to the processing demands of the passages. Such an alternative interpretation would argue that the third sentence in the backward passages (the filler sentence) was so unexpected that it resulted in the slowing of the reading process. Recall that the backward passages presented the inference sentence in the second position, with the inducing sentence not following until the fourth position. It is possible that the presence of the filler sentence in the third position effectively interrupted the flow of events, and was the cause of the slow-down. This alternative hypothesis was examined in a series of 3 post-hoc analyses comparing reading times for sentences 1-3 in both the backward and explicit versions. Since version type is the variable of interest, only main effects and interactions involving the type factor will be discussed. As before, only results significant by both F_1 and F_2 will be discussed.[5]

In the first two analyses, where reading times for the first and second sentences were compared across passage versions, type was not involved in any significant effects. In the third analysis, a main effect for type was qualified by a grade by type interaction which was significant by subjects and marginally

significant by stories: $F_1(3,88) = 3.17$, $p < .05$, $F_2(3,66) = 2.31$, $p = .085$. Due to the importance of the reading speed effect to the overall interpretation of encoding vs. retrieval effects, this interaction was further examined by comparing the type effect at each of the four grade levels. For both grades three and five, there was a significant type effect reflecting the fact that the third sentences in the backward versions were read more slowly than in the explicit versions: $F_1(1,88) = 17.53$, $p < .001$, $F_2(1,66) = 12.37$, $p < .001$; and $F_1(1,88) = 24.03$, $p < .01$, $F_2(1,66) = 24.17$, $p < .001$, for grades three and five respectively. Type was not significant, however, for either the eighth-graders or college students. The interpretation of this analysis is that the slow-down to the backward versions seemed to begin for both the third- and fifth-graders in the third sentence, while it was not apparent in the eighth-graders and college students until the fourth sentence. It may well be that the presence of the filler sentence following the inference sentence somewhat disrupted the flow of reading for the third- and fifth-graders. It must be reiterated, however, that the slow-down did not manifest itself until the fourth sentence for both the eighth-graders and college students, seeming to support the conclusion that it was during the fourth sentence that the inferential processing took place.

Reading Condition Effects

The reading condition results obtained from the reading speed and question-answering analyses portrayed an interesting pattern of results, where it was suggested that the younger readers had more difficulty with the integrative condition while the older readers had more difficulty with the superficial condition. Due to the suggestive nature of this pattern, the data from the two youngest grades and the two oldest grades were collapsed, and post-hoc analyses were conducted. The overall analyses (both F_1 and F_2) for both reading speed and question-answering latencies were recomputed utilizing this newly combined data set.[4] These data are shown in Figure 1.

Insert Figure 1 about here

Turning first to the reading speed analyses, the grade by condition interaction was significant, $F_1(1,92) = 9.18$ $p < .01$, $F_2(1,23) = 47.69$, $p < .001$. Simple effects analyses confirmed the trend suggested in the original analyses. In both the subjects and stories analyses, the two youngest groups of readers read the fourth sentences of the stories more quickly in the superficial reading condition than in the integrative reading condition. The reverse held true for the two older groups. For them, the integrative reading condition led

to faster reading times as compared to the superficial reading condition. The pattern of results in the question-answering latency analyses were similar as well, where the grade by condition interaction was once again significant, $F_1(1,88) = 6.01$, $p < .05$, $F_2(1,21) = 8.91$, $p < .01$. Simple effects analyses revealed that the pattern of the young readers mirrored that seen in the reading speed analyses: Questions were answered more quickly in the superficial reading condition than in the integrative reading condition. With the older readers, however, the pattern of significance was slightly different. Although neither the F_1 nor F_2 simple effects analyses reached significance, the pattern of results was consistent with that obtained previously.

These two post-hoc analyses suggest an interesting pattern of behavior for the younger and older readers: The younger readers found the superficial stories more easy to deal with whereas the older readers performed better on the integrative stories. A possible interpretation of this finding may be that the younger readers experienced difficulty in the integrative reading task due to its highly demanding processing requirements. The reading condition manipulation used here actually made the study analogous to a dual-task study, where the subjects were required to read the stories in order to answer questions accurately as well as read each story with a specific purpose in mind

(extrapolating beyond the given information). It is amply documented that young children experience difficulty dividing their attention between two simultaneous tasks (see Guttentag, 1985, for a recent discussion) In the present case, the integrative reading task may have been so demanding to the younger readers that it utilized a significant proportion of their available resources. One way the younger readers may have compensated was to slow the reading process so that inferential performance would not concomitantly suffer.

The plausibility of the above explanation is strengthened when recent work by Zack and her colleagues dealing with the effects of aging on inferential performance is considered (Zacks & Hasher, 1988; Zacks, Hasher, Doren, Hamm, & Attig, 1987). Zacks and her colleagues have found that while older adults often show inferior inference performance relative to young adults, an important mediating variable is the mode of presentation of the texts. If allowed to engage in self-paced reading, rather than listening to an oral presentation, age differences in inference performance are greatly attenuated. Zacks argues that by slowing the rate of reading, older adults are more able to compensate for working memory deficits. This would appear to be what occurred in the present experiment. Although the children (third- and fifth-graders) in the integrative condition read the stories and answered the

questions more slowly compared to the children in the superficial condition, their performance on the inference questions was actually better.

Although he stressed differences in processing resources rather than differences in working memory capacity, Guttentag (1985) has argued along similar lines. Guttentag (1985) suggests that the performance of older adults and young children on different types of memory tasks may be similar due to an effectively smaller attentional pool from which to allocate processing resources. It makes no difference whether the attentional pool itself is actually smaller for young children and older adults, or if the ability to allocate attentional processes is less efficient; the end result is the same - impaired performance. Slowing the reading process would be one way of compensating for a smaller attentional pool.

The eighth-graders and college students probably found the integrative reading task easier because their pool of attentional resources and working memory were functioning at maximum capacity. As a result, they did not suffer from the shortcomings ascribed to the younger children. Additionally, reading for comprehension is a much more natural task for an experienced reader than is searching and remembering a capitalized word. Given their extensive experience with an educational system which stresses the integration and

comprehension of reading material, it should not be surprising that the young adults found the integrative reading task to be easier. The superficial reading condition probably interrupted the older readers' natural flow, thereby causing a slowing in reading.

Summary and Conclusions

Perhaps the most striking finding which emerged from the analyses, and one which needs little argument to be compelling, is that the subjects at all of the grade levels successfully drew the inferences. Even the third-grade subjects evidenced no difficulty at drawing the inferences, although this ability did increase with age.

The results of the present study also support the conclusion that the backward inferences were drawn at encoding while the forward inferences were not drawn until retrieval. While this point is well-accepted among researchers working with adult readers, only one other known developmental study exists supporting this claim (i.e., Casteel & Simpson, in press). This conclusion is made even more compelling when the differences between the Casteel and Simpson study and the present one are considered: the stories differed, the length of the stories differed, and the number of the stories differed. In addition, the present study used a story type (explicit) and dependent measure

(reading speed) not used in the previous study. In fact, it is the inclusion of the reading speed measure which lends the most direct support to these conclusions.

The present results also support the conclusion that even young elementary school-aged children are sensitive to the effects of textual support in a story. In fact, the four grade levels were similarly affected by the degree of textual support provided the two types of inferences. While the speed of responses was slower, and the percentage of errors was higher for the youngest children as compared to the adults, the overall pattern of responding for the two groups was virtually identical. There is now ample support that even young grade school children are sensitive to the processing demands placed upon them by a textual stimulus, and that they can spontaneously draw an appropriate inference when it is made necessary for comprehension. While not as skilled as adult readers, children as young as second or third grade do possess the requisite skills necessary to draw appropriate inferences as they read. It is readily apparent, then, that the amount of textual support provided an inference is a critical determinant of the ease with which that inference is drawn by the reader.

One of the most surprising findings was the effect the reading condition manipulation had on the younger and older subjects. Although it was hypothesized that readers would slow their reading of the fourth sentences in the backward versions (reflecting the inferential processing), this slow-down was not restricted to the inference versions, but included explicit stories as well. In addition, only the younger subjects slowed their reading in the integrative condition. The older subjects were actually faster in the integrative condition.

These age effects are intriguing, and were attributed to differences in working memory capacity, processing resources, and general reading experience. These conclusions, however, must be viewed as tentative at best, as the analyses on which they are based were completely post-hoc. Future research is clearly necessary before any definitive conclusions can be reached.

References

Black, J. B. (1981). The effects of reading purpose on memory for text. In J. Long & A. Baddeley, (Eds.), Attention and performance IX (pp. 347-361). Hillsdale, NJ: Erlbaum.

Black, J. B., & Bern, H. (1981). Causal coherence and memory for events in narratives. Journal of Verbal Learning and Verbal Behavior, 20, 267-275.

Carpenter, P. A., & Just, M. A. (1977). Reading comprehension as eyes see it. In M. A. Just & P. A. Carpenter (Eds.), Cognitive processes in comprehension. Hillsdale, NJ: Erlbaum.

Casteel, M. A., & Simpson, G. B. (in press). Journal of Research in Reading.

Danner, F. W., & Mathews, S. R. (1980). When do young children make inferences from prose? Child Development, 51, 906-908.

Dosher, B. A., & Corbett, A. T. (1982). Instrument inferences and verb schemata. Memory & Cognition, 10, 531-539.

Graesser, A. C., Haberlandt, K., & Koizumi, D. (1987). How is reading time influenced by knowledge-based inferences and world knowledge? In B. K. Britton & S. M. Glynn (Eds.), Executive control processes in reading (pp. 217-251). Hillsdale, NJ: Erlbaum.

Guttentag, R. E. (1985). Memory and aging: Implications for theories of

memory development during childhood. Developmental Review, 5, 56-82.

Haberlandt, K. F., Graesser, A. C., Schneider, N. J., & Kiely, J. (1986). Effects of task and new arguments on word reading times. Journal of Memory and Language, 25, 314-322.

Johnson, H., & Smith, L. B. (1981). Children's inferential abilities in the context of reading to understand. Child Development, 52, 1216-1223.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. Psychological Review, 87, 329-354.

Kail, R., & Bisanz, J. (1982). Information processing and cognitive development. In H. W. Reese (Ed.), Advances in child development and behavior (pp. 45-81). New York: Academic Press.

Keenan, J. M., Baillet, S. D., & Brown, P. (1984). The effects of causal cohesion on comprehension and memory. Journal of Verbal Learning and Verbal Behavior, 23, 115-126.

Keenan, J. M., Golding, J. M., Potts, G. R., Jennings, T. M., & Aman, C. J. (1990). Methodological issues in evaluating the occurrence of inferences. In A. C. Graesser & G. H. Bower (Eds.), The psychology of learning and motivation, Volume 25: Inferences and text comprehension (pp. 197-212).

San Diego: Academic Press.

Keenan, J. M., & Kintsch, W. (1974). Memory for information inferred during reading. In W. Kintsch (Ed.), The representation of meaning in memory. Hillsdale, NJ: Erlbaum.

McKoon, G., & Ratcliff, R. (1986). Inferences about predictable events. Journal of Experimental Psychology: Learning, Memory & Cognition, 12, 82-91.

Millis, K. K., Morgan, D., & Graesser, A. C. (1990). The influence of knowledge-based inferences on the reading time of expository text. In A. C. Graesser & G. H. Bower (Eds.), The psychology of learning and motivation, Volume 25: Inferences and text comprehension (pp. 197-212). San Diego: Academic Press.

Mosenthal, P. (1976-1977). Psycholinguistic properties of aural and visual comprehension as determined by children's abilities to comprehend syllogisms. Reading Research Quarterly, 12, 55-92.

O'Brien, E. J., Shank, D. M., Myers, J. L., & Rayner, K. (1988). Elaborative inferences during reading: Do they occur on-line? Journal of Experimental Psychology: Learning, Memory, & Cognition, 14, 410-420.

Omanson, R. C., Warren, W. H, & Trabasso, T. (1978). Goals, inferential comprehension, and recall of stories by children. Discourse Processes, 1,

337-354.

Potts, G. R., Keenan, J. M., & Golding, J. M. (1988). Assessing the occurrence of elaborative inferences: Lexical decision versus naming. Journal of Memory and Language, 27, 399-415.

Reder, L. M. (1980). The role of elaboration in the comprehension and retention of prose: A critical review. Review of Educational Research, 50, 5-53.

Schmidt, C. R., & Paris, S. G. (1983). Children's use of successive clues to generate and monitor inferences. Child Development, 54, 742-759.

Schmidt, C. R., Schmidt, S. R., & Tomalis, S. M. (1984). Children's constructive processing and monitoring of stories containing anomalous information. Child Development, 55, 2056-2071.

Seifert, C. M., Robertson, S. P., & Black, J. B. (1985). Types of inferences generated during reading. Journal of Verbal Learning and Verbal Behavior, 24, 405-422.

Singer, M. & Ferreira, F. (1983). Inferring consequences in story comprehension. Journal of Verbal Learning and Verbal Behavior, 22, 437-448.

Thompson, J. G., & Myers, N. A. (1985). Inferences and recall at ages four and

seven. Child Development, 56, 1134-1144.

Whitney, P. (1987). Psychological theories of elaborative inferences: implications for schema-theoretic view of comprehension. Reading Research Quarterly, 22, 299-310.

Zabrucky, K. (1986). The role of factual coherence in discourse comprehension. Discourse Processes, 9, 197-220.

Zacks, R. T., & Hasher, L. (1988). Capacity theory and the processing of inferences. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 154-170). New York: Cambridge University Press.

Zacks, R. T., Hasher, L., Doren, B., Hamm, V., & Attig, M. S. (1987). Encoding and memory of explicit and implicit information. Journal of Gerontology, 42, 412-422.

Footnotes

[1]This latter analysis was based on only 23 of the possible 24 stories due to missing data. The empty cell occurred when the four subjects whose data comprised the cell responded that the backward inference did not occur in that particular story. Reading speeds were counted as valid only if a given subject responded during the questioning routine that the inference had in fact occurred. The logic of this requirement is straightforward, as an increase in reading time taken to read the fourth sentence of the backward versions is expected to reflect the fact that the appropriate inference is being generated at that point. If the inference is not accepted, the reading speed data for that inference is meaningless. This point is not viewed as problematic, as it reflects the simple fact that readers differ in the extent to which they are willing to infer various plausible outcomes even given the 80% norming criterion.

[2]Only 17 stories entered into the stories analysis, again due to a number of empty cells (for the same reasons as those outlined in the previous footnote). The smaller number of valid stories is largely due to the responses to the forward inference questions. The fact that the forward inferences were not necessary for comprehension made them much less likely to be drawn by the readers. If all four subjects in a particular cell claimed that an inference did

not occur, its reaction time was not entered into any analyses. Therefore, the construction of the stimuli virtually ensured that a number of the forward inferences would probably not be drawn by the readers. Although it is unfortunate that the analyses are not based on all of the stories, it is argued that the results are still valid, as the pattern of results is essentially identical to that obtained in both the reading speed and error percentage analyses.

[3]The error percentage data are based on the full complement of 24 stories, unlike the two previous analyses.

[4]These post-hoc analyses were felt to be justified for two reasons. The first concerns the consistent trend noted in both the reading speed and question-answering latency analyses. The trend was simply too consistent to be ignored. The second reason concerns the added power given to the analyses, as the new reading speed F_2 analysis is based on all 24 stories while the new question-answering latency F_2 analysis is based on 22 of the 24 stories.

[5]Although the third sentences were the only sentences which were not exactly the same in the two versions, a t-test conducted on the average words per sentence did not reveal any significant differences: $t(23) = 1.25$, $p > .10$.

Table 1

Three Versions of a Sample Story and Questions Common to all Versions

Forward Inference Story	
Lori washed her clothes one afternoon.	(Filler)
Lori lay in the sun while she waited.	(Filler)
The clothes were done in one hour.	(Filler)
Lori hung her wash out on the sunny day.	(Forward inference)
Backward Inference Story	
Lori washed her clothes one afternoon.	(Filler)
Lori hung her wash out on the sunny day.	(Backward inference)
The sun made the clothes smell fresh.	(Filler)
Lori only had to wait one hour.	(inducing sentence)
Explicit Inference Story	
Lori washed her clothes one afternoon.	(Filler)
Lori hung her wash out on the sunny day.	(Backward inference)
The clothes all dried in the sun.	(Explicit inference)
Lori only had to wait one hour.	(Inducing sentence)
Questions	
Did Lori wash her clothes in the afternoon?	(Filler question)
Did the clothes dry in the sun?	(Inference question)

Table 2

Mean Reading Speeds and Standard Deviations (in Msec) to the Fourth Sentences in the Backward and Explicit Story Versions

	Superficial		Integrative	
	Backward	Explicit	Backward	Explicit
Grade 3				
Mean	2585	2455	2982	2804
S.D.	683	780	771	559
Grade 5				
Mean	2257	2107	2623	2287
S.D.	485	561	618	509
Grade 8				
Mean	2099	2007	1738	1594
S.D.	681	565	464	385
Adults				
Mean	2006	1964	1763	1611
S.D.	311	358	407	373

Table 3

Mean Reaction Times and Standard Deviations (in Msec) to the Questions

	Superficial			Integrative		
	FR	BK	EX	FR	BK	EX
Grade 3						
Mean	3635	3114	2822	4339	3454	3186
S.D.	966	622	527	915	958	588
Grade 5						
Mean	2786	2710	2409	3112	2732	2503
S.D.	502	424	334	308	355	315
Grade 8						
Mean	2290	2039	1824	2084	1902	1820
S.D.	511	312	324	544	552	349
Adults						
Mean	2654	2346	2033	2222	2067	1774
S.D.	580	468	362	807	666	425

(FR - Forward Inferences)
(BK - Backward Inferences)
(EX - Explicit Inferences)

Table 4

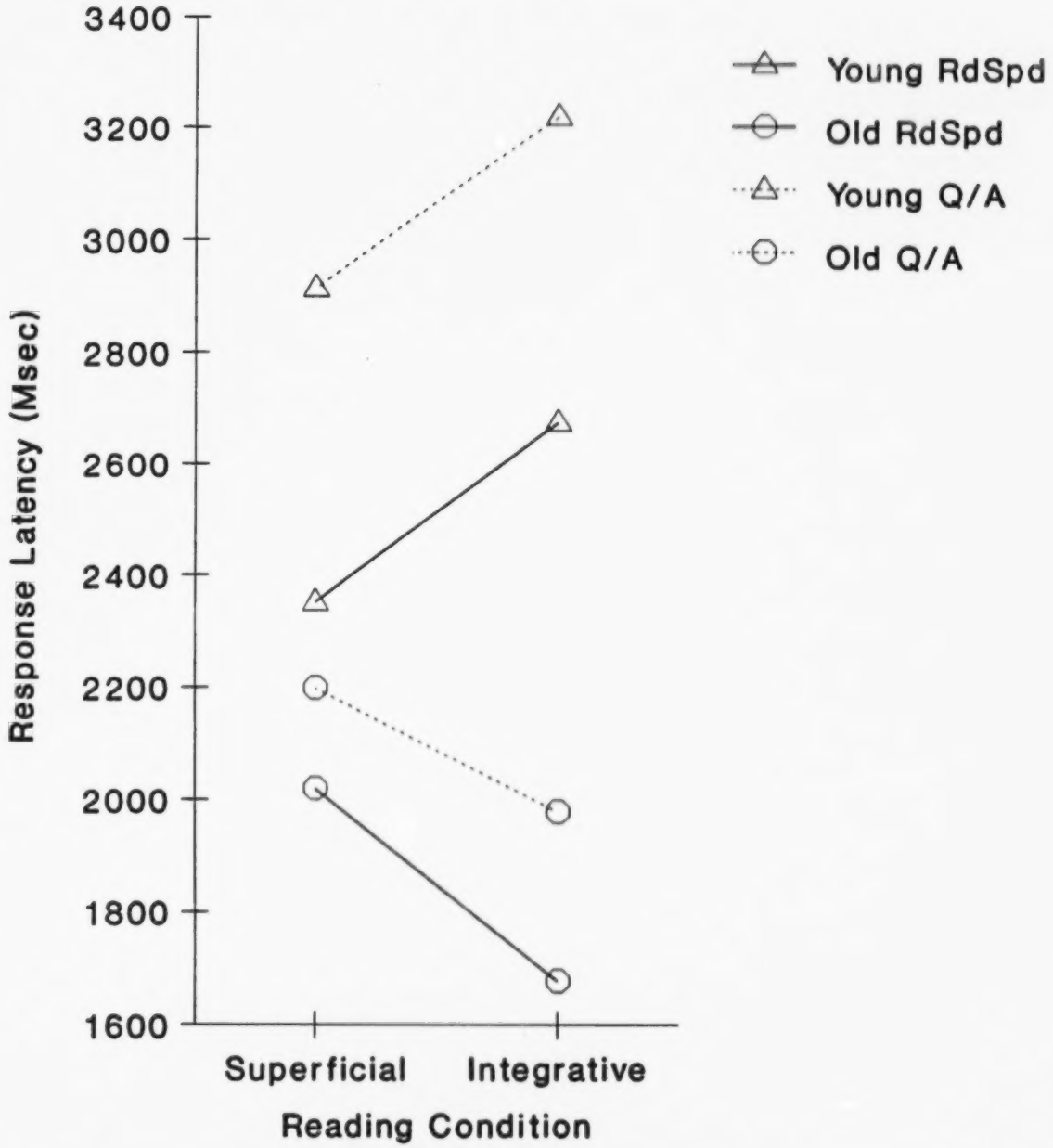
Mean Proportion of Errors for Each Type of Inference Question

	Superficial			Integrative		
	FR	BK	EX	FR	BK	EX
Grade 3						
Mean	.33	.25	.18	.30	.21	.07
S.D.	.13	.18	.20	.14	.18	.10
Grade 5						
Mean	.46	.20	.05	.31	.21	.05
S.D.	.10	.17	.11	.16	.12	.08
Grade 8						
Mean	.38	.16	.04	.26	.07	.05
S.D.	.21	.18	.08	.22	.10	.10
Adults						
Mean	.49	.16	.05	.36	.19	.04
S.D.	.22	.16	.08	.19	.14	.08

(FR - Forward Inferences)
(BK - Backward Inferences)
(EX - Explicit Inferences)

Figure Caption

Figure 1. Reading speeds to the fourth sentences and question-answering latencies to the inference questions as a function of age group (young/old) and reading condition.



(RdSpd - Reading Speed of 4th Sentences)
(Q/A - Question-Answering Latencies)